LITTLE COLORADO RIVER FISH MONITORING
2006 ANNUAL REPORT

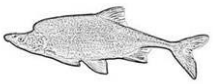

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TABLE OF CONTENTS

INTRODUCTION

In 1987, the Arizona Game and Fish Department (AGFD) began monitoring of fishes in the Little Colorado River (LCR) to assess population trends and status of the endangered humpback chub (*Gila cypha*) (HBC)(Robinson and Clarkson 1992). Annual standardized hoop net sampling is conducted for 20 – 30 days each spring to capture humpback chub during the spawning period (Table 1). This program was discontinued in 2000 but then reinstated in 2002 at the advice of the Grand Canyon Monitoring and Research Center Protocol Evaluation Panel (Anders *et al*. 2001). Catch-per-unit-effort (CPUE) indices derived from this monitoring program are useful as independent validation for mark-recapture population models of humpback chub developed by Coggins *et al*. (2006). With the exception of 2000-2001, the lower 1200 meter sampling represents one of the most consistent, long-term sampling methods for Grand Canyon fishes.

STUDY SITE

The study site is the lower LCR, 1,200 m upstream from its confluence with the Colorado River. The LCR in the study area is a deeply entrenched channel located in a vertical-walled canyon that in places narrows to less than 50 m. The LCR channel contains runs, riffles, deep pools and small rapids. Substrates are primarily silt and sand with scattered large boulders and travertine dams. The LCR is the primary spawning site for the endangered HBC in Grand Canyon and is the only known HBC aggregate in the Colorado River Ecosystem from which fish are known to recruit into the adult population (Valdez and Ryel 1995; Coggins and Walters 2001). Other native fishes, bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and speckled dace (*Rhinichthys osculus*) spawn in the LCR (Robinson *et al*. 1998) as do exotic species including channel catfish (*Ictalurus punctatus*), fathead minnow (*Pimephales promelas*), red shiner (*Cyprinella lutrensis*), common carp (*Cyprinus carpio*) and black bullhead (*Ameiurus melas*).

METHODS

We fished thirteen standardized AGFD hoop nets continuously from April 14 through May 7, 2007, checking nets once daily. Hoop nets measured 5 m long and 1 m diameter with 6.3 mm mesh, 7 hoops and two throats. Nets were set at 100, 119, 137, 165, 420, 480, 500, 577, 675, 1045, 1110, 1160, and 1195 m upstream from the confluence. Net locations were set as

close as possible to those used in previous sampling efforts (Brouder and Hoffnagle 1998). Catch per unit effort was calculated as number of fish caught per hour.

All fish caught were handled following protocols in Ward (2002). All fish collected were identified to species and measured for total length (TL; nearest mm). Fork length was also measured for humpback chub, flannelmouth sucker, and bluehead sucker. Weights were not measured in an effort to reduce handling time and because high winds common during the study period do not allow accurate weight measurements. Analysis of previous weight data from this monitoring program also indicates these weights are not useful as an index of fish condition because they are confounded by sexual condition and tapeworm loads. Native fish were sexed when possible based on external sexual characteristics or manual expulsion of gametes and sexual condition (not ripe, ripe, spent) was recorded. Examination of sexual characteristics (none, color, tuberculate) was also noted. Number and type of external parasites were recorded. Native fish ≥ 150 mm TL were scanned for the presence of a Passive Integrated Transponder (PIT) tag with both new 134.2 kHz tag reader and an old 400 kHz tag reader to verify that no tags were missed. If a tag was not found and the fish was ≥ 150 mm TL, a 134.2 kHz PIT tag was inserted into the abdominal cavity. Tag presence or absence and PIT tag number were recorded. Fish were also checked for fin clips or elastomer dye (marks used in previous years to identify tag loss or fish translocated above Chute Falls) (Stone and Sponholtz 2003). PIT tag information was downloaded electronically and checked for errors.

RESULTS

A total of 2,925 fish representing 10 species were captured in the LCR during standardized monitoring in 2007. Native species dominated the catch and comprised 98 % of total fish caught (Table 3). Speckled dace, humpback chub, bluehead sucker, and flannelmouth sucker, were the predominant species caught (Table 3 & 4). Catch rates of native fishes were higher than in 2006 and have comprised over 90 % of the total catch since 2002, with the exception of 2006 (Figure 6). Catch rates of bluehead suckers in 2005 and 2006 remain at the highest level that has been recorded since monitoring began in 1987 (Table 5, & Figure 9).

The LCR was at or near base flow during the entire 2007 sampling period (Figure 4) with relatively low turbidity that decreased during the sampling period (Figure 5). In general, turbidity during the entire sampling period was below 10 NTU (Figure 5). Water temperature ranged from 14 to 25 ºC during the sampling period (Figure 7).

Native species

Humpback chub

A total of 587 humpback chub were collected in standardized hoop net sets during the 2006 monitoring period. Most of the fish caught in 2006 were less than 150 mm TL (Table 4) with less than half as many chub over 150 mm TL caught in 2006 as in 2005.

We examined 95 humpback chub ≥ 150 mm TL for presence of a PIT tag and 62 (65 %) were PIT tag recaptures (Table 4, Appendix). Four hundred and ninety two humback chub (< 100 mm TL) were caught; with the smallest being 43 mm TL, although most (346) were between 70 and 99 mm TL (Table 7). Only two ripe male HBC were found in 2006 and no ripe female chub were collected. Sixty eight humpback chub were reported with at least one *Lernaea* during 2006 sampling as opposed to 26 fish with *Lernaea* in 2005 and only one fish in 2004 (Figure 12). Of the 62 new tags that were inserted 39 of them were put into fish over 250 mm TL indicating that over half of the HBC that were tagged were previously untagged older fish and not young fish recruiting into the population.

Flannelmouth sucker

Flannelmouth sucker were the third most abundant native species captured (483, 8 %) in 2006 (Table 3) with at least three distinct cohorts of fish captured (Figure 2). A total of 333 flannelmouth suckers over 150 mm TL were caught and 120 (36 %) were recaptures (Table 4). CPUE of flannelmouth suckers has been highly variable during the last 4 years but still indicates an increasing trend since 2002 (Figure 9).

Bluehead sucker

Bluehead suckers caught in 2006 had a mean TL of 139 mm and ranged in size from 34 to 334 mm TL. A large cohort of age-0 bluehead suckers was detected in 2006 indicating spawning of bluehead suckers may have occurred relatively early in 2006 and age-0 blueheads were large enough to be captured during the sampling period (Figure 3). A total of 189 bluehead suckers were scanned for presence of a PIT tag, with 8 recaps (4.2 %). CPUE of bluehead suckers in 2005 and 2006 are the highest that have ever been observed since monitoring began in 1987.

Speckled dace

Speckled dace were the most abundant species caught in 2006 with 3,173 individuals caught (Table 3). CPUE of speckled dace is highly variable among years but recent data suggests an increasing trend since about 2002 (Figure 9).

Nonnative species

Nonnative species made up 23 % of the total catch in 2006 with fathead minnow being the most abundant nonnative species caught (Table 3). This is a dramatic increase over 2005 sampling where no fathead minnow or red shiners were caught.

DISCUSSION

Native species

Catch rates of native fishes in 2006 were generally higher than in 2005 which can be partially attributed to the low turbidity and baseflow conditions during most of the sampling period (Figure 4 & 5). Recent investigations of the effects of turbidity on hoop net catch rates have revealed that turbidities < 180 NTU increase catch rates significantly (Stone 2004). Fish may use the nets as cover in clear water. In general, catch rates of native fish show an overall increasing trend since 2002.

Humpback chub

The mean CPUE of humpback chub ≥ 150 mm TL shows severe declines from 1987 to 1994 and has remained relatively stable since about 1994 (Figure 8). It may be that the pre-1987 population of humpback chub represented individuals that were born prior to or during the time in which Lake Powell was filling when mainstem Colorado River water temperatures were warmer and the mainstem Colorado River was humpback chub habitat. Since about 1994 the number of humpback chub has been relatively stable at a lower level. This may indicate that the present chub population represents the carrying capacity of the Little Colorado River alone and the higher pre-1987 chub population represented the carrying capacity of the mainstem Colorado River and the Little Colorado River. The trout removal efforts near the confluence of the Little Colorado River that ended in the winter of 2006 should help to address the question of whether or not the mainstem Colorado River is actually humpback chub habitat. If chub numbers do not increase as a result of these efforts it may be that the mainstem Colorado River is still not humpback chub habitat possibly because of the cold water temperatures, even after predators are

removed. Warmer mainstem water temperatures because of drought conditions and low water levels in Lake Powell will make interpretation of recent increases in CPUE of native fish even harder to interpret. CPUE of humpback chub 151-199 mm TL has been slightly higher in 3 of the last 4 years but still do not show any clear trends (Figure 8). Although large numbers of age 0 and 1 humpback chub have been caught in the last 3 years of sampling, length frequency histograms do not indicate these young humpback chub are transitioning into larger adult fish (Figure 1). Sixty two percent of the humpback chub recaptured in 2006 in the Little Colorado River have been at large for over 12 years (Appendix). This indicates a large portion of the spawning population of humpback chub is comprised of very old individuals. If substantial recruitment of young fish into the spawning population does not occur further population declines are likely. Nine recaptured humpback chub were previously caught in the mainstem Colorado River within 10 miles of the confluence with the LCR. None of the humpback chub recaptured in 2006 showed long distance movements from other areas of the mainstem Colorado River.

Flannelmouth sucker

In 2006, mean CPUE of flannelmouth sucker was higher than in 2004 and 2005 and represents an increasing trend since 2002 (Figure 9). Catch rates of flannelmouth suckers collected in the Little Colorado River and in the mainstem Colorado River within Grand Canyon between 1991 and 2000 suggested that the population of flannelmouth suckers was stable with few strong year classes and was dominated by age 0 fish (< 150 mm TL) and adults (> 400 mm TL). Recent monitoring in the Little Colorado River (2002-2006) as well as electrofishing in the mainstem shows evidence of increased abundance of sub-adult flannelmouth suckers. This trend is most evident in mainstem electrofishing data between 233 km and 346 km downstream of Glen Canyon Dam (Scott Rogers AGFD, personal communication). The observed trend corresponds temporally and spatially to an increased number of days with water temperature greater than 15°C (Figure 11). It is likely that increased river temperatures resulting from lower Lake Powell water levels and stable summer discharges from Glen Canyon Dam are partially responsible for the increased recruitment of flannelmouth suckers within the Little Colorado River.

Bluehead sucker

Catch of bluehead suckers ≥ 150 mm TL decreased from 2005 levels, but still show an increasing trend since 2002. CPUE of bluehead suckers in 2005 and 2006 are the highest that have ever been recorded since monitoring began in 1987 (Figure 9). At least three distinct cohorts of bluehead suckers were caught in 2006 (Figure 3). Warmer mainstem water temperatures caused by drought conditions and lowered water levels in Lake Powell (Susan Hueftle, USGS unpublished data) may have led to increased survival of suckers. The removal of rainbow trout in the area around the confluence of the Little Colorado River may also be partly responsible for the increased catch of suckers within the Little Colorado River. Although separating the effects of warmer water and fewer predators may not be possible, the overall effect appears to have been beneficial to sucker populations. Eight bluehead suckers were recaptured in 2006, but no individuals had been at large for over 1.5 years (Appendix).

Catch of speckled dace is highly variable among years, but do show an increasing trend within the last 3 years (Figure 9). Warmer mainstem water temperatures and fewer introduced predators are expected to benefit speckled dace populations, as well as humpback chub and sucker populations.

Nonnative species

The percentage of nonnative fishes in the Little Colorado River continues to remain at low levels (Figure 6). There is some indication that the number of fathead minnows has increased since 1994 although high variation in catch rate between years makes trends difficult to assess (Figure 10). The catch rate of fathead minnows in 2006 was higher than has ever been recorded since monitoring began in 1987. The increase in fathead minnow catch rate may also be a result of increased mainstem water temperatures. Catch rate of red shiner also appears to have increased since 2002 (Figure 10). Black bullhead has shown higher variability in catch since 1995 (Figure 10). Catch of channel catfish is also highly variable creating very large confidence intervals surrounding the mean. This makes it difficult to assess trends for channel catfish although there are indications of an increasing trend since 2002 (Figure 10). No trends are evident in catch rate of common carp (Figure 10). Adult carp are not very susceptible to capture in hoop nets within the Little Colorado River so hoop net catch trends are not likely to be a good index of the carp population.

The pattern of nonnative fish abundance in the Little Colorado River is not typical of most southwestern streams. Typically, once small bodied introduced species such as fathead minnow or red shiner appear they gradually increase in abundance over time until they numerically dominate (Reviewed in Marsh and Pacey 2005). The extreme flood regime and high turbidity of the Little Colorado River during the spring and late summer may prevent these nonnative species that are adapted for more stable systems from becoming established (Minckley and Meffe 1987, Ward et al. 2003). If the mainstem Colorado River continues to be warm because of drought conditions fathead minnow and red shiner may be able to become established in the mainstem and invade the Little Colorado River between flood events much more quickly.

Strengths of lower 1200 meter monitoring

The lower 1200 meter hoopnet monitoring represents one of the longest ongoing trend indexes for Grand Canyon fishes. The real strength of this data set is the length of time over which the data has been collected in a consistent manner. Catch-per-unit-effort (CPUE) indices derived from the lower 1200 meter monitoring show dramatic declines in CPUE of adult humpback chub and validate mark-recapture population estimates. This index of catch rate is also valuable as an independent method to confirm output of age-structured mark/recapture (ASMR) open population models. The lower 1200 meter standardized hoop net monitoring should be continued as a means of comparing catch rate data with population estimates from the Fish and Wildlife Service and validating age structured mark-recapture stock assessment models produced by the Grand Canyon Monitoring and Research Center.

Additional projects done in conjunction with lower 1200 meter monitoring

Several small studies were undertaken in 2006 in conjunction with lower 1200 meter fish monitoring to answer specific questions related to native fish. A short summary of each of these projects follows along with recommendations based on the results of those studies.

Remote detection of PIT tags

Recent technological advances and 134.2 kHz PIT tags have allowed new possibilities for remote detection of fish, which may help address questions of fish movement and population closure within the Little Colorado River. We evaluated the potential of remotely detecting PIT tags in fish using these continuous underwater Pit tag scanners (CUPS) to remotely detect tags in moving fish without handling them. This is the third year of experimentation using this new technology. Two 11-inch diameter antennas, and one larger 24-inch square antenna were

fastened in either the final hoop of a baited Fyke net (1/4 inch mesh, 1 m basket, 6 hoops and 3, 15 m leads) or in the final hoop of a large mesh hoop net (1 inch mesh, 6 hoops). The CUPS antennas were downloaded daily and fished between 17 - 26 nights in three separate locations near Boulders Camp. These remote antenna's detected a total of 141 unique tags, 15 of which were old 400 Khz tags. For comparison, the total number of unique PIT tags recaptured from the thirteen standard monitoring nets was 167. Three fish were caught in both the standardized lower 1200 monitoring nets and in the auto detect antennas.

The use of larger batteries and additional solar panels this year helped the units to run for longer periods of time but they were still unable to operate continuously. This type of non-intrusive sampling with a remote antenna could be used in conjunction with a temporary weir to answer questions about population closure, spawning and movement patterns of humpback chub in the Little Colorado River. Only 21 fish that were detected by the auto detect antenna were also caught in the nearby baited hoopnet. This may indicate that capture efficiency in hoopnets is low and fish may be somewhat trap shy. We believe it is time to move past the experimental phase of this project and implement remote detection of PIT tags in the Little Colorado River on a larger scale.

Removal and quantification of Asian tapeworm

Thirty humpback chub were captured in May, 2006 in conjunction with lower 1200 meter monitoring efforts and treated with praziquantel to remove Asian tapeworm (*Bothriocephalus acheilognathi*) according to protocols established in the laboratory (Ward 2006). No mortality or abnormal behavior was noted in any of the humpback chub that were treated. Tapeworm infestation in humpback chub from the Little Colorado River was highly variable but all size classes appeared had some degree of infestation. Tapeworm infestation in 2006 (80 %) was higher than in 2005 (38.7 %) (Figure 13). The difference in infestation is likely the result of baseflow conditions in 2006 which are more conducive to tapeworm proliferation. This methodology appears to be a good, non-lethal method for quantifying tapeworm loads in endangered fishes. We propose to continue monitoring tapeworm loads in humpback chub in the Little Colorado River using this methodology. This monitoring will allow baseline information to be gathered that will be needed to assess the impacts of warmer mainstem water temperatures on Asian tapeworm populations, as well as impacts of Asian tapeworm infestation on humpback chub.

Large mesh, baited hoop net

A baited 1-inch mesh hoopnet (1.0 meter diameter with 6 hoops) was also fished in front of Boulder Camp for 20 nights. This net was originally set to capture fish for photos but proved so effective at catching adult humpback chub that it was continued for the duration of the trip. One hundred and thirty six humpback chub over 200 mm TL were caught in this net which consisted of 112 unique tag numbers (Table 6). A separate file with a unique trip ID (LC20060411) was submitted for this data so that catches are not confused with data from standardized monitoring. Mean CPUE of HBC in the baited hoopnet was 0.31 fish per hour (95 % CI 0.44 – 0.18). For comparison, this is 10 times the catch rate of HBC in the 2006 lower 1200 meter monitoring. It may be that the larger mesh size and larger diameter of the net is more conducive to capture of adult humpback chub. Mean TL of humpback chub caught in the baited hoopnet was 391 mm (Range 237 – 475) (Figure 14). This gear type may be a good method for catching large numbers of adult chub and needs further evaluation.

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TABLES

Table 1. Little Colorado River hoop netting effort by year, 1987 – 2006.
This is only HN gear types fished during April and May in the Lower 1200 meters of the Little Colorado River.

Year	Effort (Hours)	Days
1987	1428	21
1988	3668	26
1989	4920	25
1990	4479	27
1991	7773	58
1992	6038	55
1993	9116	31

Year	Effort (Hours)	Days
1994	9987	32
1995	9449	30
1996	9175	30
1997	9076	31
1998	7060	21
1999	9373	25
2000	0.00	0

Year	Effort (Hours)	Days
2001	0.00	0
2002	3138	30
2003	3415	25
2004	7190	23
2005	6333	26
2006	7417	24

Table 2. Trip dates and number of net sets 1987 - 2006.

Lower 1200 meter LCR trips					Average duration of set	
Year	Start	End	Trip ID	Days	in hours	# of net sets per year [a]
1987	9-May	30-May	LC19870509	21	11.52	124
1988	3-May	29-May	LC19880503	26	11.15	329
1989	3-May	28-May	LC19890503	25	24.00	205
1990	17-Apr	14-May	LC19900417	27	23.70	189
1991	3-May	30-Jun	LC19910503	58	14.56	534
1992	5-May	28-May	LC19920505	23	18.93	319
1993	30-Apr	31-May	LC19930430	31	12.25	744
1994	19-Apr	21-May	LC19940419	32	12.27	814
1995	20-Apr	20-May	LC19950420	30	12.01	787
1996	18-Apr	18-May	LC19960418	30	12.25	750
1997	13-Apr	14-May	LC19970413	31	12.05	753
1998	5-Apr	26-Apr	LC19980405	21	16.38	431
1999	7-Apr	1-May	*GC19990406	24	18.86	497
2002	19-Apr	19-May	LC20020419	30	24.14	130
2003	11-Apr	9-May	LC20030411	28	24.75	138
2004	9-Apr	3-May	LC20040409	24	24.05	299
2005	8-Apr	6-May	LC20050408	26	23.99	264
2006	7-Apr	5-May	LC20060407	24	24.44	312

[a] This number represents all hoop nets set within the lower 1200 meters of the LCR during the months of April and May but does not include Fyke nets or D hoop nets.
* 1999 has a GC extension because it was submitted with USFWS downstream data.
From 1993 to 1997 nets were often checked twice daily which led to a higher number of net sets.

Table 3. Catch by species, lower 1200 m hoop net monitoring, Little Colorado River, April 7 - May 5, 2006. Total effort = 7417.32 hours of soak time.

Species	Number	%
Bluehead sucker (BHS)	395	6.56
Flannelmouth sucker (FMS)	483	8.02
Humpback chub (HBC)	587	9.75
Speckled dace (SPD)	3173	52.69
Total Native	**4638**	**77.02**
Black bullhead (BBH)	12	0.20
Channel catfish (CCF)	13	0.22
Common carp (CRP)	19	0.32
Fathead minnow (FHM)	1286	21.36
Plains killifish (PKF)	9	0.15
Rainbow trout (RBT)	1	0.02
Red shiner (RSH)	44	0.73
Total Non-native	**1384**	**22.98**
Total	**6022**	**100**

Table 4. Numbers of fish scanned, tagged, and recaptured by species during LCR lower 1200 meter hoopnet monitoring, 2006.

Species	<150 mm TL	> 150 mm TL	New tags inserted	Recaps	Total Catch
BBH	9	3			12
BHS	206	189	181	8	395
CCF	11	2			13
CRP	11	8			19
FHM	1286				1286
FMS	150	333	211	120	483
HBC	492	95	62	62	587
PKF	9				9
RBT		1			1
RSH	44				44
SPD	3173				3173

* Total Effort = 7,417.32 hours of soak time

Table 5. Total Catch of species by year, LCR standardized hoop net monitoring 1987 – 2006.

Species	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2002	2003	2004	2005	2006
BBH									1		1	1			3	5	4	12
BHS	39	65	72	25	106	19	44	64	32	413	45	27	61	122	93	154	347	395
CCF	5	8	41	2	4	8		5	1	1	12	5	10	1	3	7	3	13
CRP	2	1							1	8	60		5		7	7	1	19
FHM	1	12	17	10	3	1	1	265	19	237	726	52	14	46	42	91		1286
FMS	81	91	28	30	106	25	50	88	65	237	97	6	21	79	256	357	192	483
GSH	1																	
HBC	396	596	548	418	316	199	431	657	243	359	123	132	156	130	157	743	344	587
PKF											97	1		1		52		9
RBT			1		1		2		1	8	1	4	6	3		5	1	1
RSH			2							14	74	8	70	3	13	65		44
SPD	132	192	204	90	1003	110	455	1022	488	741	417	106	187	115	116	1918	445	3173
SUC				3			1			2								

Table 6. Numbers of fish caught, tagged, and recaptured by species in baited hoopnet with 1-inch mesh, set in front of Boulder Camp in 2006.

Species	New tags inserted	Recaps	Total Catch
BBH	N/A	N/A	1
BHS	6	0	6
FMS	6	1	8
HBC	48	84	136

Table 7. Length frequency distribution of fish collected during LCR sampling, April 7 – May 5, 2006.

	Species										
Length	BBH	BHS	CCF	CRP	FHM	FMS	HBC	PKF	RBT	RSH	SPD
20 - 29						1					
30 - 39		7			1	12					1
40 - 49		37			43	22	1			12	4
50 - 59		71			411	19	1	8		29	189
60 - 69		44			546	13	18	1		2	996
70 - 79		19			239	21	61				693
80 - 89	1	9			19	17	145				484
90 - 99	1	4	4		4	13	131				241
100 - 109	2	1	1			11	70				93
110 - 119	3	2	2	2		6	29				22
120 - 129	1	2	1	5		8	17				
130 - 139	1	6	1	3		4	6				
140 - 149		4	1	1		3	13				
150 - 159		1		2		3	4				
160 - 169	1	8		3		7	2				
170 - 179		5	1	1		8	2				
180 - 189		8				9	4				
190 - 199	1	21		1		26	1				
200 - 209	1	29				27	6				
210 - 219		23				29	2				
220 - 229		21				22	5				
230 - 239		20				23					
240 - 249		20				29	4				
250 - 259		13				12	6				
260 - 269		6	1			19	2				
270 - 279		4				10	1				
280 - 289		3				4					
290 - 299		4				2	1				
300 - 309		1				5	2		1		
310 - 319						9	1				
320 - 329		1				5	1				
330 - 339		1				8					
340 - 349						5	1				
350 - 359						5	2				
360 - 369						9	2				
370 - 379						6	2				
380 - 389						15	5				
390 - 399						11	7				
400 - 409						4	11				
410 - 419						7	8				
420 - 429						5	5				
430 - 439						2	7				
440 - 449						3	1				
450 - 459						2					
460 - 469											
470 - 479											
480 - 489											
490 - 499						1					
500 - 509											
510 - 519						1					
520 - 529											
530 - 539											
540 - 549											
550 - 559											
560 - 569											
570 - 579				1							

FIGURES

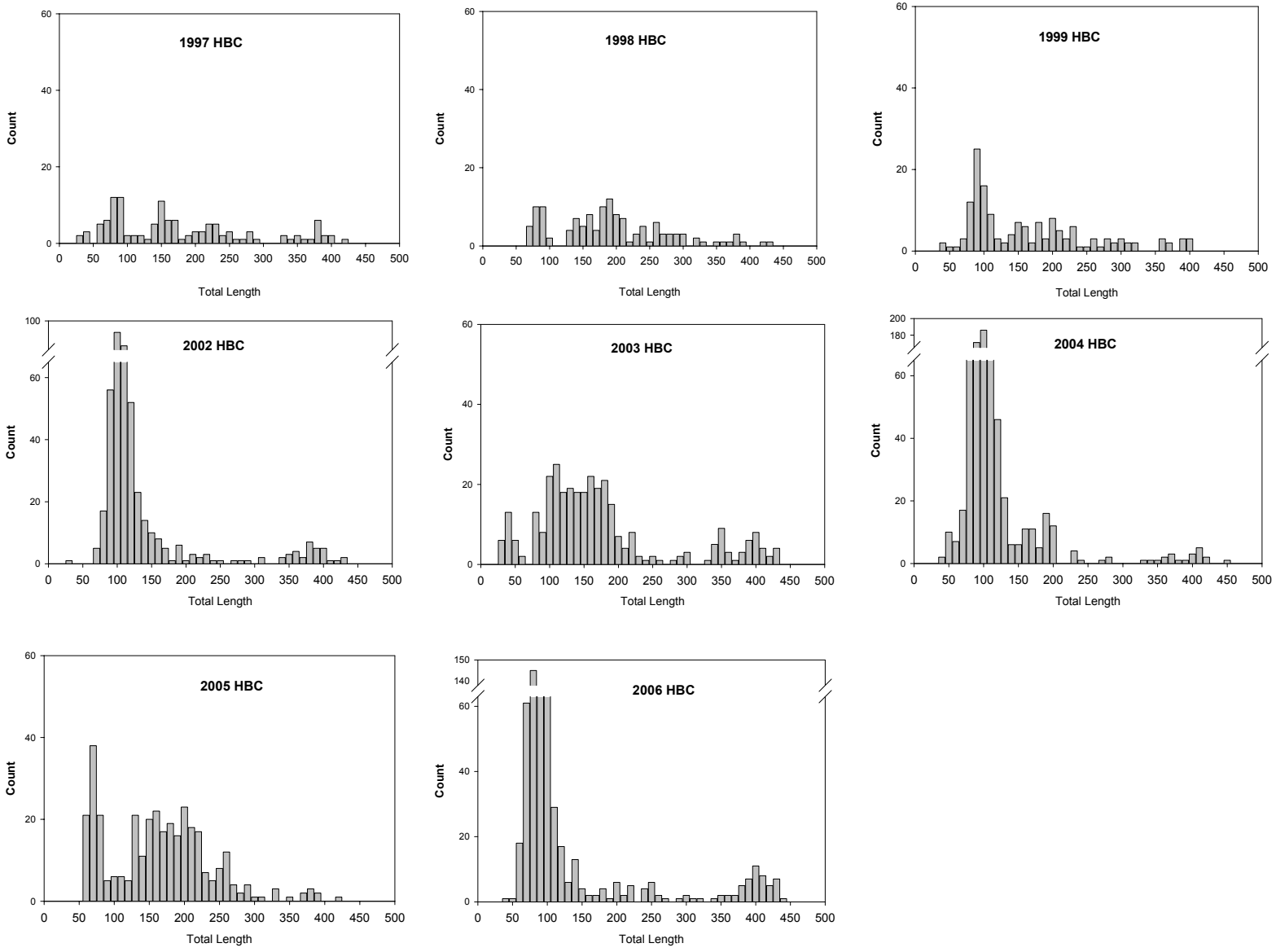


Figure 1. Length frequency distributions for humpback chub (HBC), caught in the Little Colorado River during the most recent 8 years of monitoring.

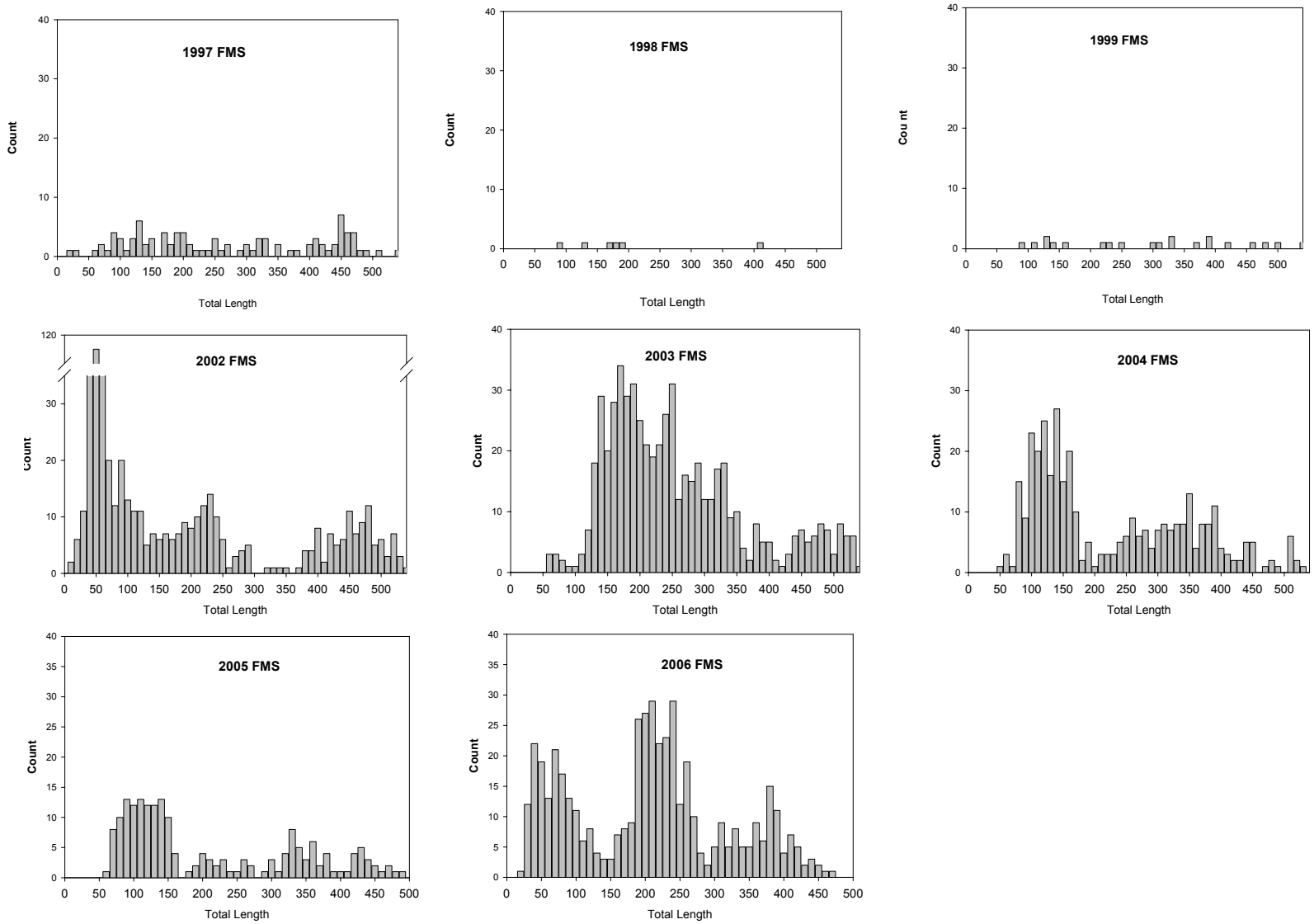


Figure 2. Length frequency distributions of flannelmouth sucker (FMS), caught in the Little Colorado River during the most recent 8 years of monitoring.

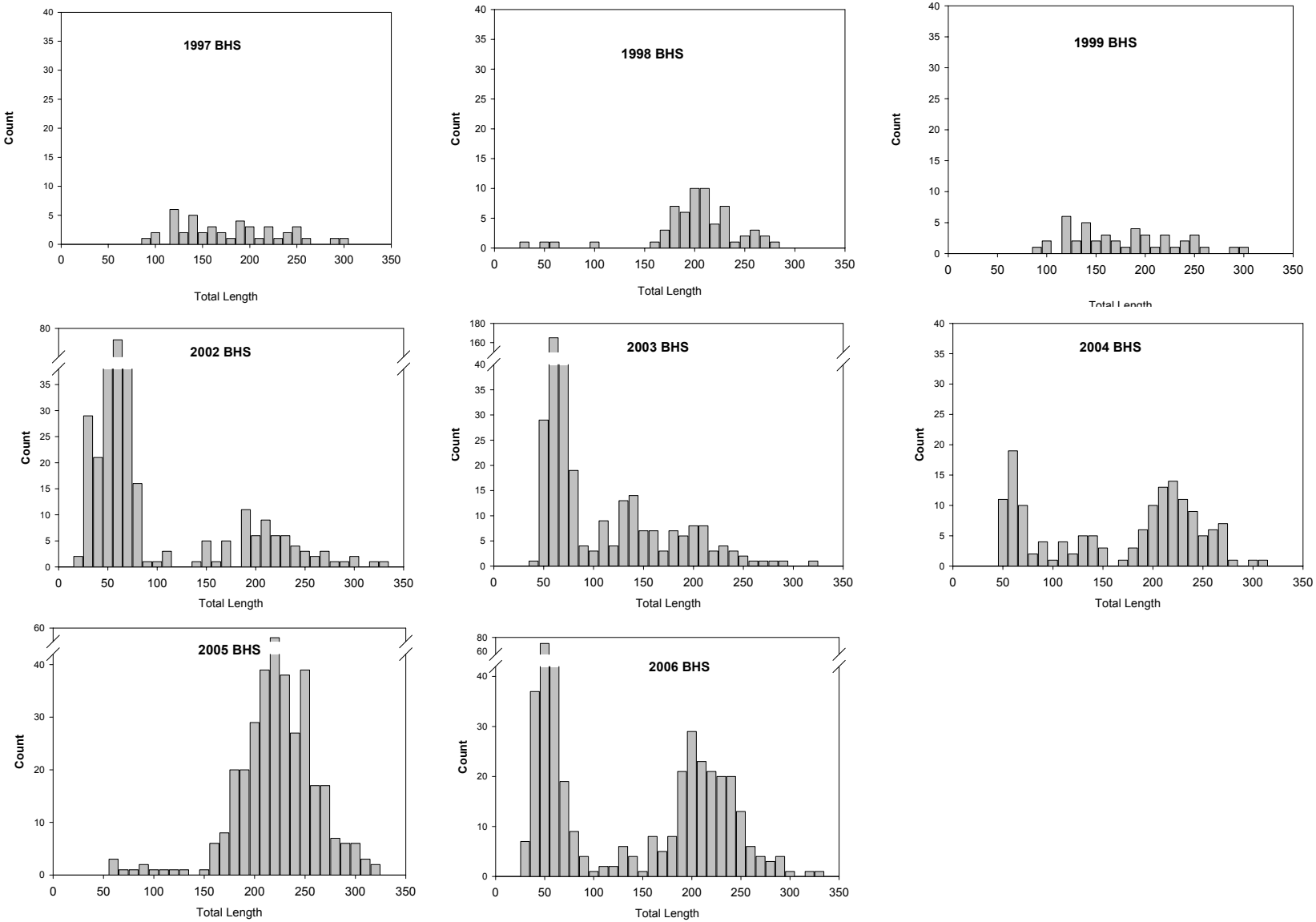


Figure 3. Length frequency distributions of bluehead sucker (BHS), caught in the Little Colorado River during the most recent 8 years of monitoring.

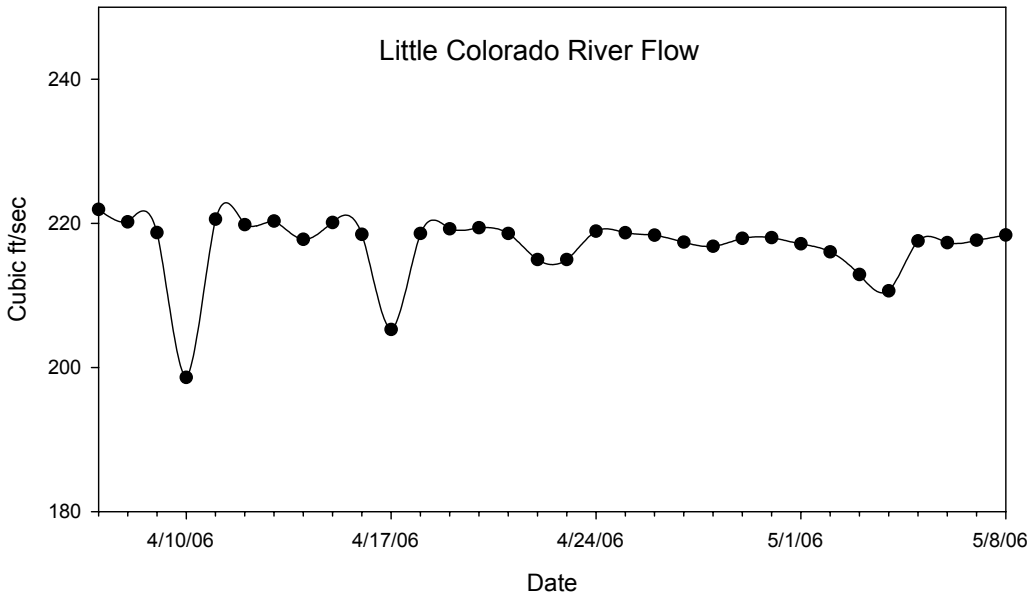


Figure 4. Mean daily flow of the Little Colorado River during the sampling period in 2006. USGS gauge above confluence with the Colorado River.

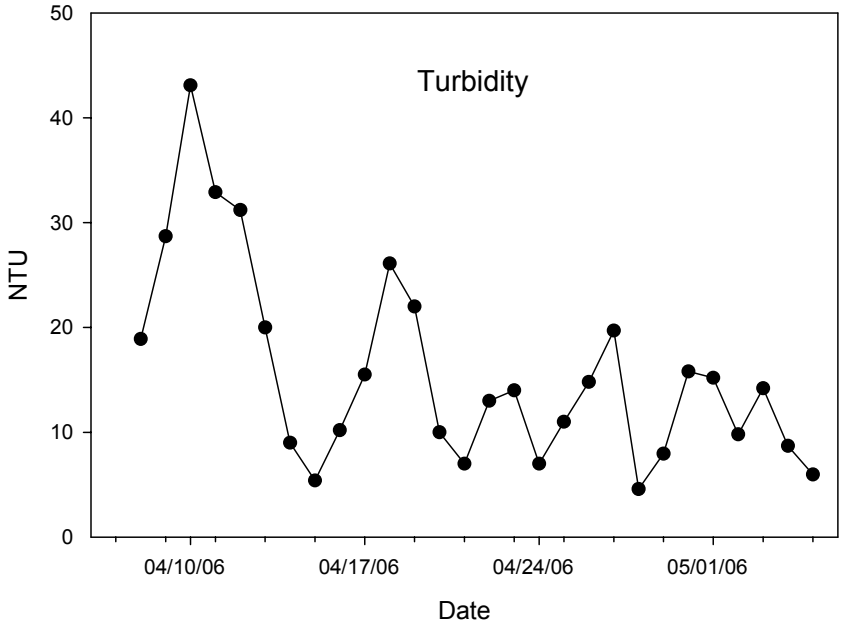


Figure 5. Mean daily turbidity (NTU's) in the Little Colorado River during 2006 sampling, Turbidity measured at Boulders Camp using a Hach 2100P Turbidimeter.

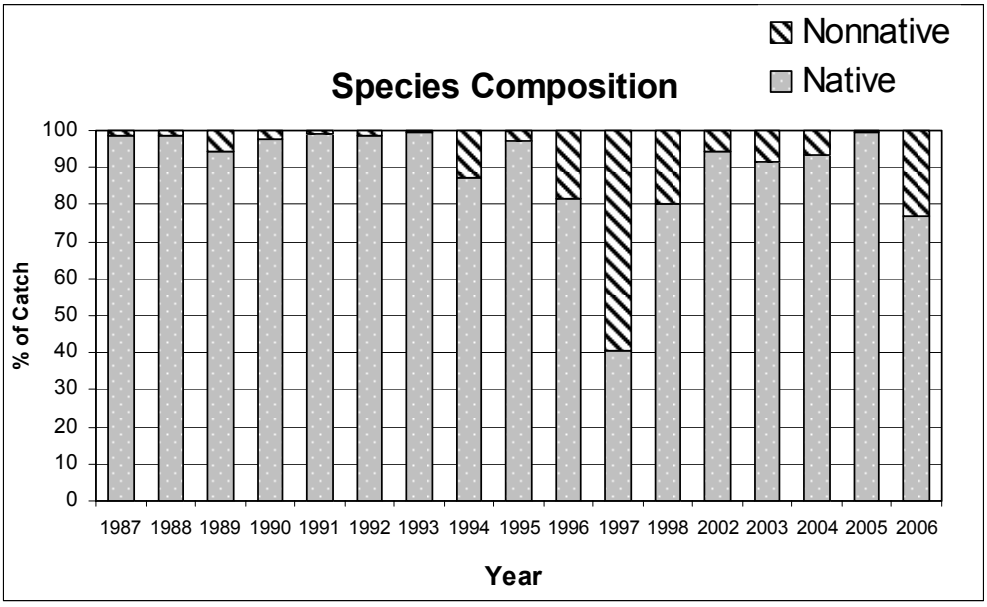


Figure 6. Species composition of fish caught in standardized hoop net monitoring, 1987 - 2006.

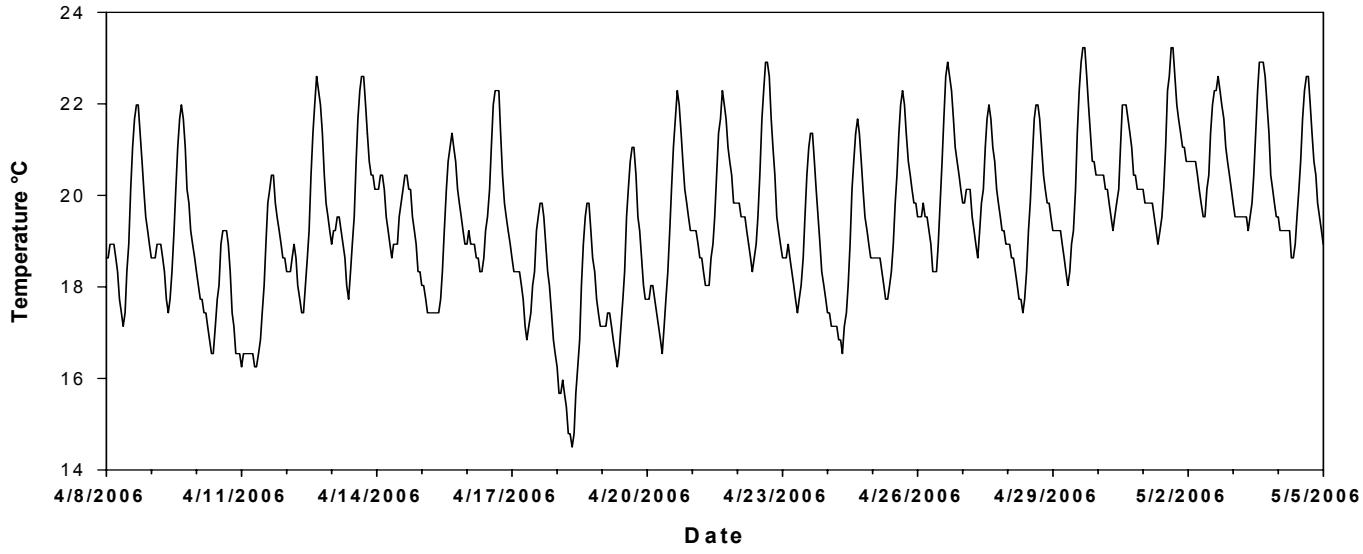


Figure 7. Daily water temperature fluctuations in the Little Colorado River during 2006 sampling as measured with an hourly Hobotemp® data logger.

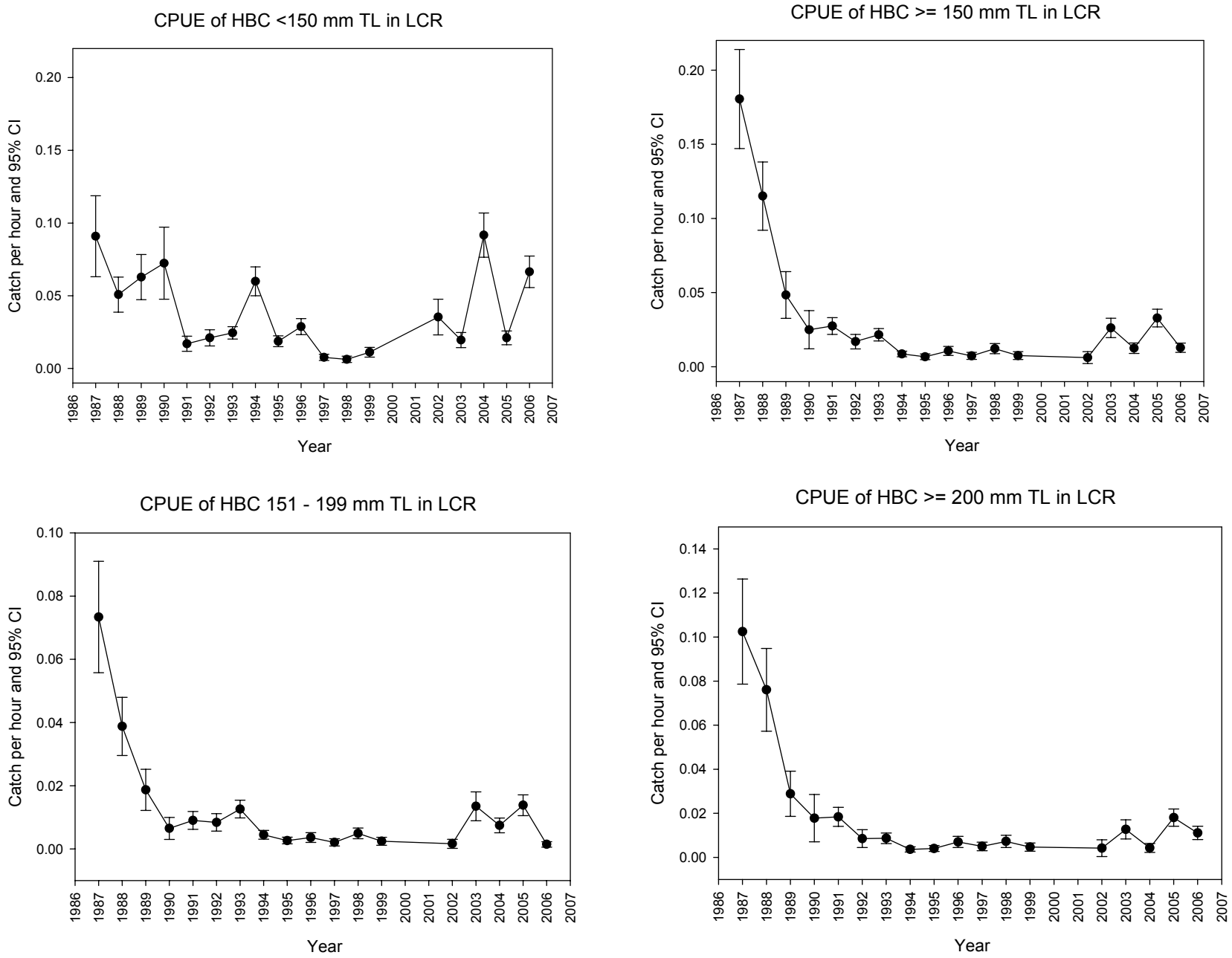


Figure 8. Mean catch/hr for 4 size groupings of humpback chub in the LCR, 1987 – 2006.

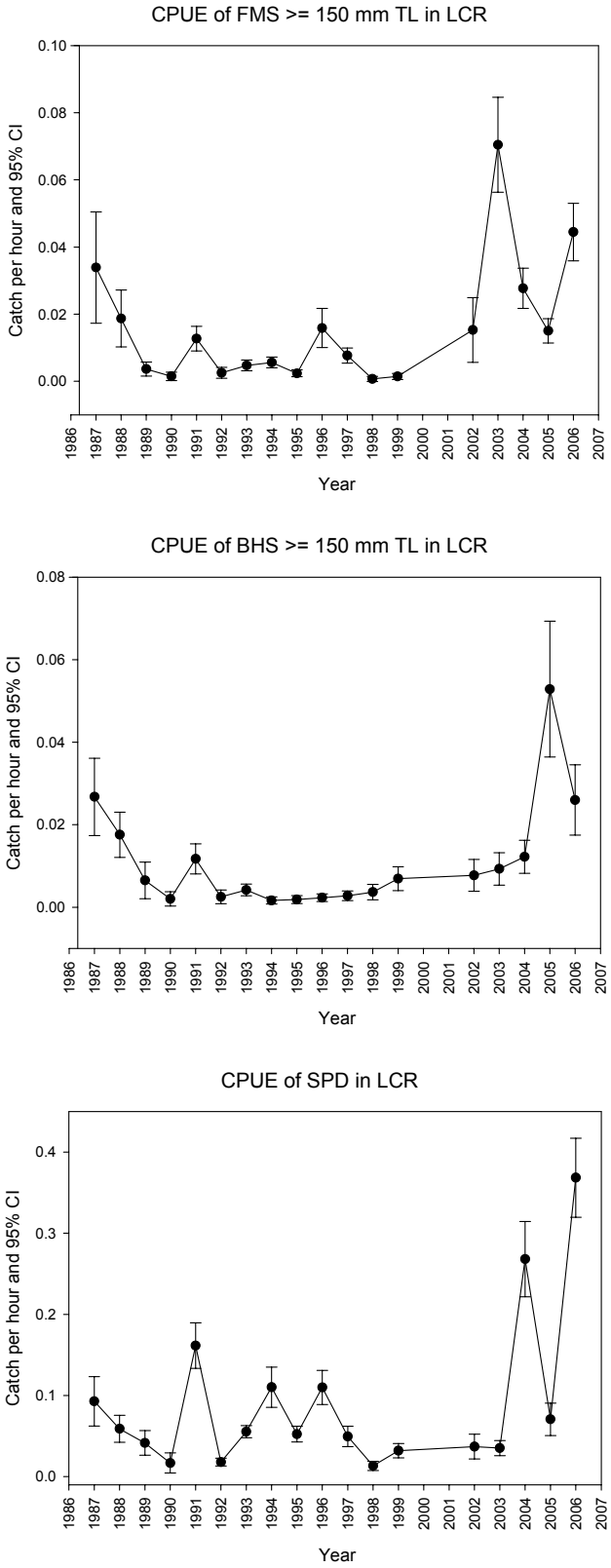


Figure 9. Mean catch/hr of flannelmouth sucker $\geq$ 150 mm TL, Bluehead sucker $\geq$ 150 mm TL and all sizes of speckled dace in the LCR, 1987 – 2006.

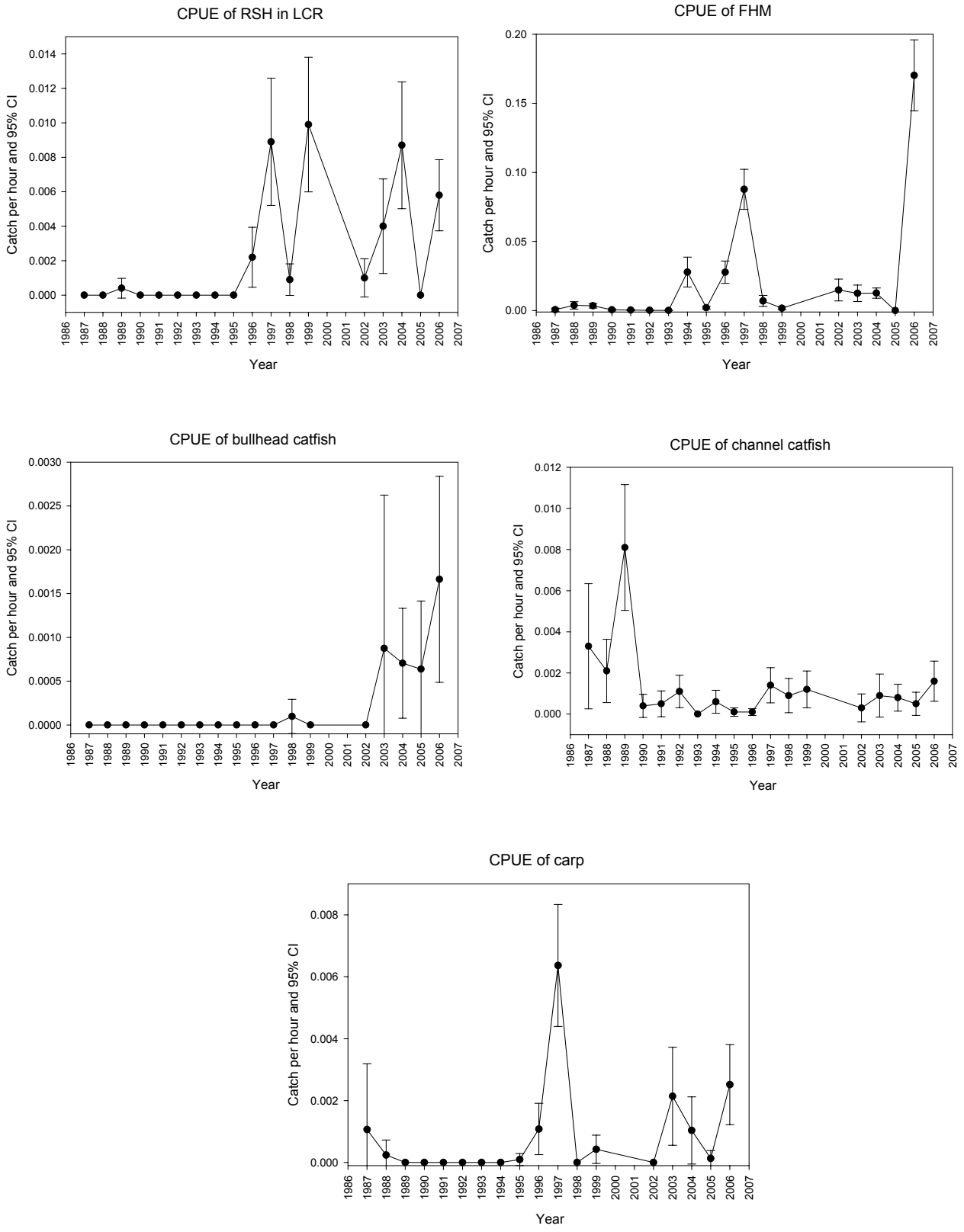


Figure 10. Mean catch/hr of nonnative fishes in the LCR, 1987-2006.

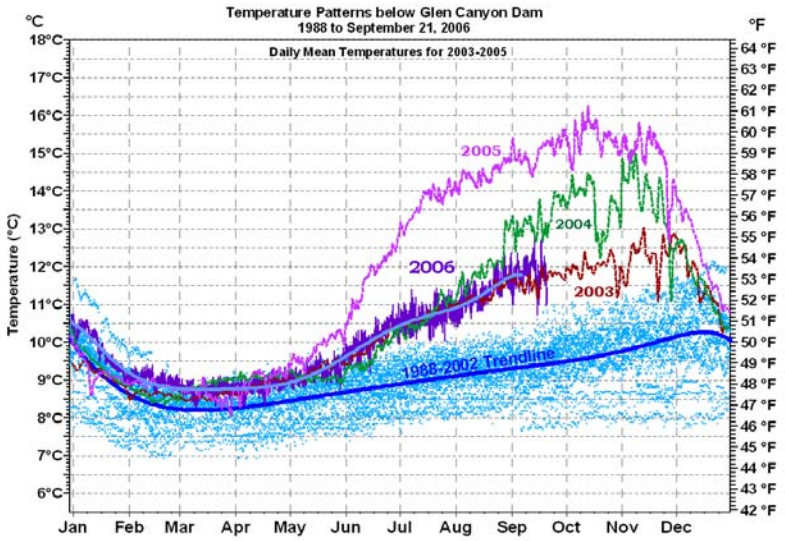


Figure created by Susan Hueftle (USGS)

Figure 11. Mainstem Colorado River water temperature below Glen Canyon Dam. Cloud of points represents 1988 – 2002 water temperatures.

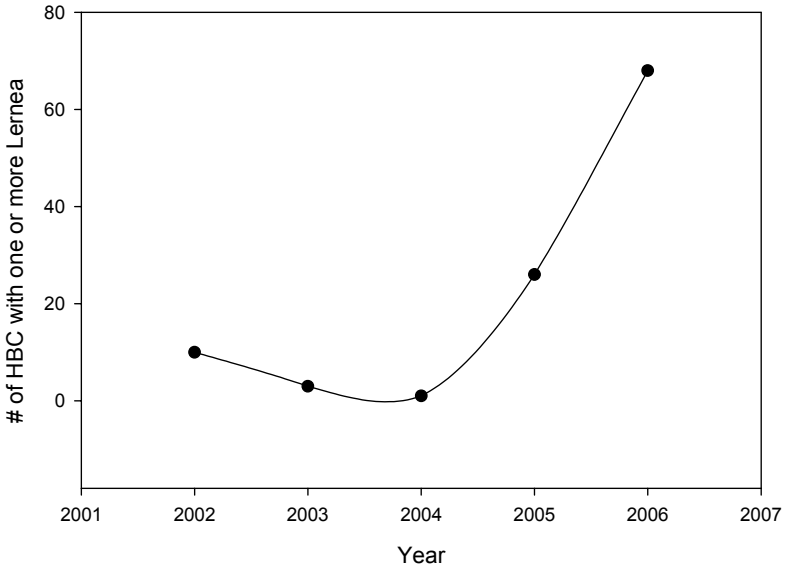
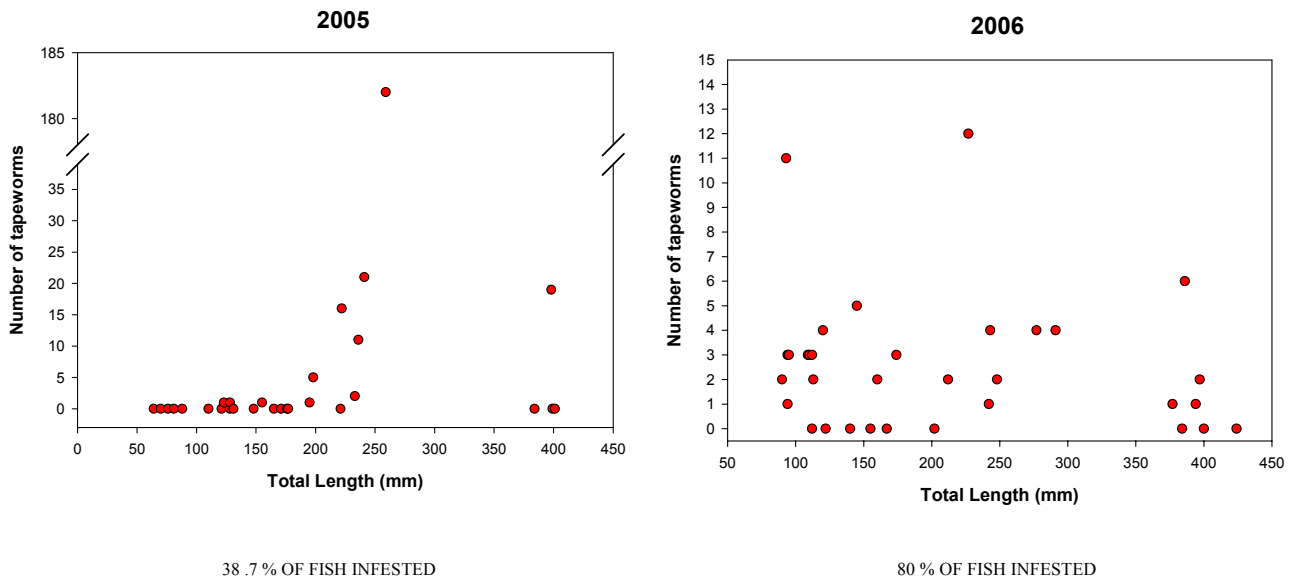


Figure 12. Incidence of *Lernea* in humpback chub from the Little Colorado River, 2002 -2006.



38 .7 % OF FISH INFESTED

80 % OF FISH INFESTED

Figure 13. Asian tapeworm removed from Humpback chub in the Little Colorado River in May of 2005 and 2006 using praziquantel bath treatments.

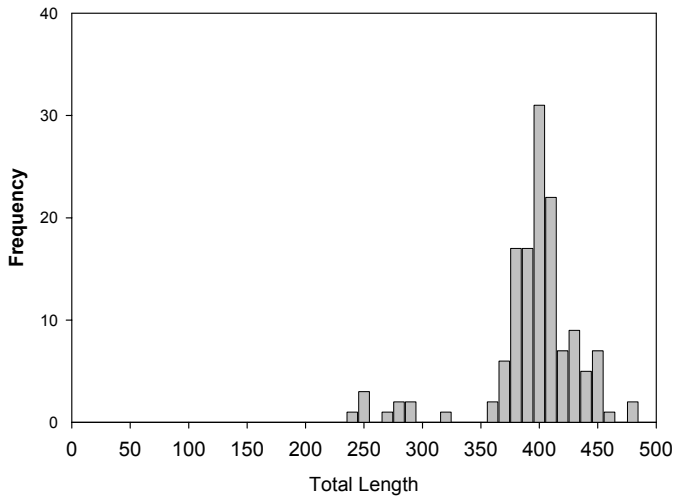


Figure 14. Length frequency distributions of humpback chub, caught in the baited, 1-inch mesh hoopnet set in front of Boulders Camp in 2006.

APPENDIX

2006 Humpback chub recapture summary (sorted by years out)

First Tag	Other Tag number	Initial Mark date	Initial TL	Final Recapture date	Final TL	Number of Times Caught	Change In TL	Total Days Out	Total Years Out
7F7F455C53	3D9.1BF2562FAC	4/26/1990	398	4/16/2006	417	2	19	5834	16.0
7F7D222632	3D9.1BF1A04759	5/31/1991	224	5/1/2006	410	8	186	5444	14.9
7F7D18456C	3D9.1BF257186D	6/22/1991	390	4/29/2006	417	4	27	5425	14.9
7F7D180179	3D9.1BF22A8640	6/16/1991	160	4/10/2006	364	5	204	5410	14.8
7F7D2B3E31	3D9.1BF1AC5C15	8/21/1991	420	4/16/2006	429	4	9	5351	14.7
7F7D177013	3D9.1BF198DE9B	8/21/1991	168	4/15/2006	398	4	230	5350	14.7
7F7D226A1E	3D9.1BF1CD63FE	8/15/1991	165	4/8/2006	354	10	189	5345	14.6
7F7F395F21	3D9.1BF1CD5247	3/6/1992	398	4/27/2006	407	6	9	5161	14.1
7F7D2B0C6F	3D9.1BF2572078	3/8/1992	383	4/19/2006	406	6	23	5152	14.1
7F7E432641	3D9.1BF2563C8E	3/11/1992	395	4/19/2006	416	4	21	5149	14.1
7F7F395437	3D9.1BF25723BA	3/12/1992	343	4/22/2006	410	10	67	5148	14.1
7F7F2C301B	3D9.1BF22A7744	3/30/1992	343	4/10/2006	399	8	56	5119	14.0
7F7F2F2103	3D9.1BF2560B34	4/23/1992	387	5/1/2006	407	5	20	5119	14.0
7F7F3E6140	3D9.1BF2561039	4/8/1992	244	4/14/2006	376	4	132	5116	14.0
7F7F7E610B	3D9.1BF24DA162	4/25/1992	346	4/22/2006	410	2	64	5108	14.0
7F7F21264E	3D9.1BF253200F	5/8/1992	376	4/23/2006	415	5	39	5096	14.0
7F7D08040A	3D9.1BF255F8AD	7/15/1992	332	4/23/2006	375	4	43	5028	13.8
7F7F337034	3D9.1BF1E92F8C	2/12/1993	339	4/13/2006	405	7	66	4804	13.2
7F7E431A74	3D9.1BF2561483	3/9/1993	398	4/26/2006	407	3	9	4795	13.1
7F7F21526A	3D9.1BF2572A00	3/9/1993	367	4/26/2006	435	4	68	4794	13.1
7F7F2A666E	3D9.1BF2538DE5	3/8/1993	364	4/17/2006	385	2	21	4787	13.1
7F7F2A6A5F	3D9.1BF2530F1E	3/9/1993	422	4/17/2006	428	3	6	4786	13.1
7F7F21726D	3D9.1BF22A92CC	3/9/1993	274	4/8/2006	397	5	123	4776	13.1
7F7D4D7D2E	3D9.1BF1D87801	5/2/1993	412	4/15/2006	423	4	11	4729	13.0
7F7F267D5E	3D9.1BF255FA0E	5/13/1993	418	4/19/2006	430	4	12	4722	12.9
1F0F72114F	3D9.1BF2562DAF	5/17/1993	384	4/13/2006	425	1	41	4714	12.9
1F20241607	3D9.1BF255FFB1	8/17/1993	319	4/20/2006	384	3	65	4627	12.7
1F46675262	3D9.1BF1D867E7	3/16/1994	340	4/28/2006	393	3	53	4424	12.1
1F7A364071	3D9.1BF2561B6C	9/18/1997	356	4/23/2006	395	3	39	3138	8.6
5321076F55	3D9.1BF2560508	4/17/2000	369	4/13/2006	385	2	16	2186	6.0
4242235B5D	3D9.1BF2572AA3	8/30/2001	392	4/16/2006	400	3	8	1689	4.6
423C786075	3D9.1BF2560041	10/2/2001	104	4/13/2006	301	3	197	1653	4.5
42424E5873	3D9.1BF2561785	4/16/2002	420	4/24/2006	420	3	0	1469	4.0
3D9.1BF195E216		4/29/2003	180	4/13/2006	258	3	78	1079	3.0
7F7D2B2A09	3D9.1BF1A0EBF6	9/20/2003	382	5/1/2006	388	2	6	953	2.6
3D9.1BF1A0EE96		4/5/2004	181	4/23/2006	261	1	80	748	2.0
3D9.1BF1AC5BB0		4/12/2004	160	4/27/2006	242	6	82	742	2.0
3D9.1BF1AC5934		4/5/2004	343	4/13/2006	350	1	7	738	2.0
7F7D180E18	3D9.1BF1992639	7/24/2004	342	4/22/2006	348	2	6	636	1.7
3D9.1BF1A08FDE		9/26/2004	176	4/28/2006	241	1	65	578	1.6
3D9.1BF1AC6183		1/15/2005	174	4/12/2006	219	2	45	451	1.2
3D9.1BF1D867E7		4/1/2005	393	4/28/2006	387	1	-6	391	1.1
3D9.1BF22A91D1		4/15/2005	215	4/11/2006	242	1	27	361	1.0
3D9.1BF1CD570F		6/19/2005	392	4/15/2006	396	1	4	299	0.8
7F7F26602A	3D9.1BF1A05506	7/11/2005	411	5/1/2006	407	1	-4	293	0.8

2006 Flannelmouth sucker recapture summary

First Tag	Other Tag number	Initial Mark date	Initial TL	Final Recapture date	Final TL	Number of Times Caught	Change In TL	Total Days Out	Total Years Out
3D9.1BF19931C1		4/19/2003	231	4/27/2006	452	3	221	1103	3.0
3D9.1BF1A0E523		5/15/2003	271	4/21/2006	445	1	174	1071	2.9
3D9.1BF198B9B4		7/26/2003	195	4/22/2006	370	5	175	998	2.7
3D9.1BF1A0E559		10/25/2003	215	4/12/2006	380	1	165	899	2.5
3D9.1BF198D45F		4/5/2004	173	5/1/2006	375	1	202	755	2.1
3D9.1BF1A01DEF		6/23/2004	277	4/25/2006	402	1	125	670	1.8
3D9.1BF1A0E25A		7/27/2004	185	4/29/2006	345	2	160	639	1.8
3D9.1BF1A04EFD		7/24/2004	165	4/15/2006	330	1	165	629	1.7
3D9.1BF1E879D0		9/15/2004	174	4/23/2006	311	1	137	585	1.6
3D9.1BF1CD3CFC		2/14/2005	190	4/10/2006	282	2	92	418	1.1
3D9.1BF1CD364D		3/19/2005	376	4/13/2006	439	1	63	390	1.1
3D9.1BF1E91BBC		4/3/2005	218	4/8/2006	305	1	87	370	1.0
3D9.1BF1AC594C		4/11/2005	205	4/12/2006	421	2	216	366	1.0
3D9.1BF22F52E2		4/30/2005	342	4/30/2006	432	1	90	364	1.0
3D9.1BF1E924DB		4/10/2005	301	4/8/2006	386	1	85	363	1.0
3D9.1BF22D5931		4/17/2005	235	4/13/2006	318	1	83	361	1.0
3D9.1BF1A50CC0		6/14/2005	280	4/15/2006	358	1	78	304	0.8
3D9.1BF1CD2319		7/15/2005	160	4/23/2006	271	1	111	281	0.8
3D9.1BF1A04B08		7/11/2005	169	4/12/2006	236	1	67	275	0.8
3D9.1BF1A0A730		7/17/2005	167	4/16/2006	266	2	99	272	0.7
3D9.1BF1CD1713		7/13/2005	371	4/8/2006	424	1	53	268	0.7
3D9.1BF1D86103		7/20/2005	275	4/10/2006	346	2	71	263	0.7
3D9.1BF22A8B72		8/8/2005	273	4/27/2006	328	2	55	261	0.7
3D9.1BF22A9565		8/12/2005	223	4/28/2006	259	1	36	259	0.7
3D9.1BF22D49E4		8/13/2005	178	4/25/2006	249	2	71	253	0.7
3D9.1BF22A7EDC		8/9/2005	169	4/13/2006	205	1	36	246	0.7
3D9.1BF229F945		8/8/2005	181	4/10/2006	248	1	67	245	0.7
3D9.1BF22A8E70		8/10/2005	182	4/9/2006	260	2	78	242	0.7
3D9.1BF22A765A		8/10/2005	152	4/8/2006	215	2	63	241	0.7
3D9.1BF22A8483		9/3/2005	168	4/21/2006	225	2	57	228	0.6
3D9.1BF1CD4FE5		9/5/2005	193	4/20/2006	245	1	52	227	0.6
3D9.1BF1E9A6A5		9/11/2005	210	4/26/2006	262	1	52	227	0.6
3D9.1BF1A05561		9/7/2005	193	4/23/2006	254	2	61	226	0.6
3D9.1BF1A0A16C		9/8/2005	182	4/23/2006	250	2	68	226	0.6
3D9.1BF1A08AC4		9/6/2005	153	4/19/2006	170	1	17	225	0.6
3D9.1BF1CD36EF		9/4/2005	176	4/17/2006	245	1	69	224	0.6
3D9.1BF1CD2B61		9/7/2005	190	4/17/2006	244	1	54	222	0.6
3D9.1BF1CD63E6		9/8/2005	175	4/19/2006	227	1	52	222	0.6
3D9.1BF1A09777		9/9/2005	154	4/18/2006	199	1	45	221	0.6
3D9.1BF1A0B2DC		9/8/2005	188	4/16/2006	239	2	51	219	0.6
3D9.1BF1A06FFC		9/5/2005	222	4/11/2006	269	1	47	218	0.6
3D9.1BF1CD658E		9/6/2005	350	4/13/2006	362	2	12	217	0.6
3D9.1BF1D87229		9/7/2005	157	4/12/2006	200	1	43	217	0.6
3D9.1BF1A0A6E5		9/7/2005	155	4/10/2006	210	1	55	215	0.6
3D9.1BF1CD25AB		9/6/2005	167	4/10/2006	216	1	49	215	0.6

2006 Flannelmouth sucker recapture summary (continued)

First Tag	Other Tag number	Initial Mark date	Initial TL	Final Recapture date	Final TL	Number of Times Caught	Change In TL	Total Days Out	Total Years Out
3D9.1BF1E91915		9/9/2005	155	4/10/2006	182	1	27	213	0.6
3D9.1BF22D4C07		9/12/2005	200	4/12/2006	240	1	40	211	0.6
3D9.1BF1CD293B		9/27/2005	174	4/10/2006	215	1	41	194	0.5
3D9.1BF1E987C1		10/26/2005	175	4/13/2006	214	1	39	169	0.5
3D9.1BF22F431C		4/9/2006	196	4/26/2006	204	1	8	16	0.0
3D9.1BF22F4726		4/13/2006	172	4/29/2006	184	1	12	15	0.0
3D9.1BF24E036A		4/9/2006	197	4/21/2006	204	1	7	11	0.0
3D9.1BF2561F6B		4/17/2006	217	4/29/2006	221	1	4	11	0.0
3D9.1BF22D4C9F		4/16/2006	200	4/25/2006	196	1	-4	9	0.0
3D9.1BF22D48E8		4/11/2006	220	4/20/2006	224	1	4	8	0.0
3D9.1BF24EDF74		4/10/2006	204	4/19/2006	205	1	1	8	0.0
3D9.1BF22A8760		4/13/2006	214	4/19/2006	215	1	1	5	0.0
3D9.1BF2560EFD		4/24/2006	312	4/29/2006	312	1	0	4	0.0
3D9.1BF22A9656		4/17/2006	234	4/21/2006	232	1	-2	3	0.0

2006 Bluehead sucker recapture summary

First Tag	Other Tag number	Initial Mark date	Initial TL	Final Recapture date	Final TL	Number of Times Caught	Change In TL	Total Days Out	Total Years Out
3D9.1BF1CD24D2		3/20/2005	191	4/25/2006	243	1	52	400	1.1
3D9.1BF1AC594C		4/15/2004	240	4/11/2005	205	1	-35	360	1.0
3D9.1BF22A76C0		8/15/2005	194	4/18/2006	209	1	15	245	0.7
3D9.1BF19F74EB		9/7/2005	183	4/21/2006	201	1	18	225	0.6
3D9.1BF1E8ECCA		9/9/2005	234	4/18/2006	260	1	26	220	0.6
3D9.1BF22A7C77		9/5/2005	187	4/8/2006	208	1	21	214	0.6
3D9.1BF1A0A34D		9/6/2005	270	4/8/2006	291	1	21	213	0.6